Space Weather Technical Forecast

Issued on Saturday, 16 July 2022 at 13:04 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1-R2 Likely throughout. Active electron fluence Likely into new week. Chance of G1 at very end of period due to CME. Further CME - awaiting imagery.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity increased to Moderate once again over the past 24 hour period, with X-ray flares at GOES16 peaking with an M1.1 flare from AR3057 at 16/0629UTC. This sunspot was one of up to seven on the solar disc at present, with almost all of this roster comprising large and mature Zurich E-groups.

Main trends in the front side sunspots were for overall growth in AR3056, 3057, 3058 and 3059, with all of this occurring in the trailing portions of the aforementioned groups apart from AR3056, which saw its leaders proliferate. The two large spot groups nearing the western solar horizon showed a more stable or slightly declining areal trend, while a newly-numbered calved off portion of AR3058 (AR3060) was an unremarkable unipolar Hsx.

One of the large filaments that have occupied the disc in recent days did finally lift off in the period - a significant northwestern quadrant feature bifurcated and largely erupted heading north and west of the Sun-Earth line between 13/1300 and 1600UTC. This was clearly visible as a partial halo in resulting Lasco imagery, with good triangulation available from STEREO A COR2. Numerous assessments of this ejecta have been carried out as further imagery has become available, and have crystallised into a most likely arrival time around the turn of the UTC day Tuesday 19 July into Wednesday 20 July.

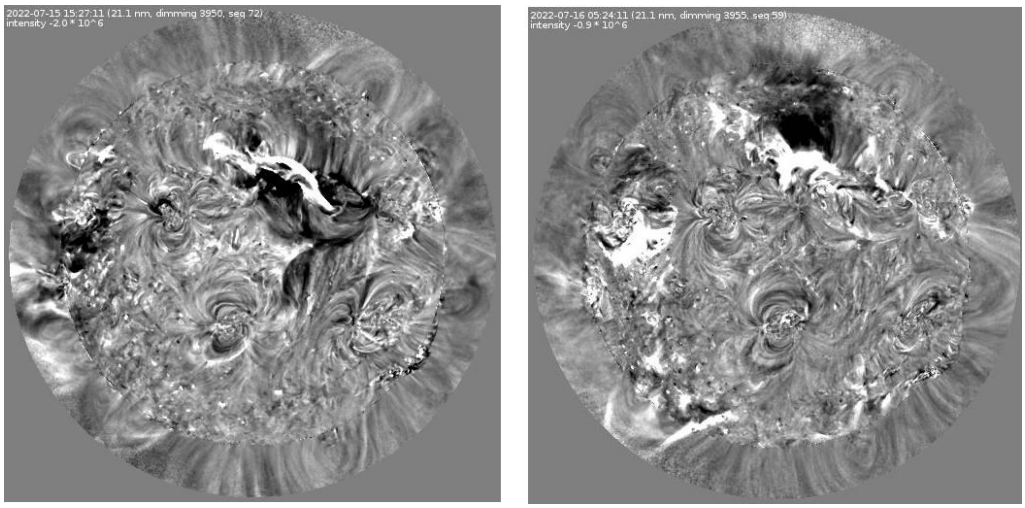

Figure 0: SIDC ROB time-integrated AIA 211 imagery of up to two large filament eruptions in the northwest quadrant. The leftmost (15/1300UTC) has a confirmed Earth-directed component, due Tuesday 19 into Wednesday 20 July; the rightmost (16/0300UTC) is as yet unconfirmed.

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Further to the above event, the de-stabilised northeastern remnant of the above filament eruption was then also seen to erupt around 16/0300-0500UTC. Resulting coronagraph imagery is not yet available for this later event, however an Earth-bound component is again very possible and analysis will be conducted when imagery allows.

In addition to the filaments, AR3058 continued its recent habit of minor flaring and narrow-angled eastward-directed CMEs. These have been modelled and are considered unlikely to have an Earth-bound component, although should this behaviour persist then this will become increasingly relevant into the new week.

One CME is therefore thought likely to be en route, that from the 15/1300UTC filament, with a second event from a similar location 16/0300UTC awaiting imagery. The former is due around 19/2359UTC; the latter to be confirmed.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, has been elevated over the past 24 hours, likely the result of a now slightly waning coronal hole high speed stream, possibly that emanating from CH99/+.

The solar wind speed was elevated throughout, with a relatively stable trend between around 550 and 575km/s, perhaps easing below 550km/s for more lasting periods later in the UTC morning. The solar wind density was slightly elevated in low double figures ppcc, but again with a slight easing trend as the period matured. The IMF was within background levels, with a peak of 8nT, but with a persistent anti-aligned character (versus the Earth's field), ranging from -6 to very brief peaks of +4nT. The phi angle was positive (away from the sun) throughout.

The net result of the above solar wind measures was Quiet to Unsettled, with a provisional peak Kp of 3- recorded at 21-24UTC and again at 06-09UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV), as measured by GOES16, was at Background levels.

The high energy electron flux (greater than 2 MeV) initially mainly Moderate, but rose to peak at High flux of 1570pfu at 16/1150UTC. The corresponding 24-hour integrated electron fluence remained well below the Active (1e8 integrated pfu) threshold, but with a rising trend and an observed value at 16/0001UTC of 1.03e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate, with a daily Slight Chance of X-class flares. Two of the current large sunspots should leave the Earth-facing side into the new week, resulting in a slight reduction in flare probability. Arriving bright flux over the eastern limb may compensate for any loss, however.

Solar Wind / Geomagnetic Activity: The 15/1300UTC filament CME is due at the very end of the current forecast period, around the turn of the UTC day Tuesday 19 into Wednesday 20 July. A second CME from a similar location produced 16/0300UTC is undergoing assessment. No other CMEs feature.

Two fast wind streams may feature in the forecast: firstly an exit from the long-peaked current CH99/+ high speed stream; and secondly minor influence from CH03/- on day four (Tuesday 19 July).

All considered, activity should soon decline to Quiet, but increase to a (probably protracted) Chance of G1 on Tuesday 19 July from the combined effect of the 15 July CME mentioned

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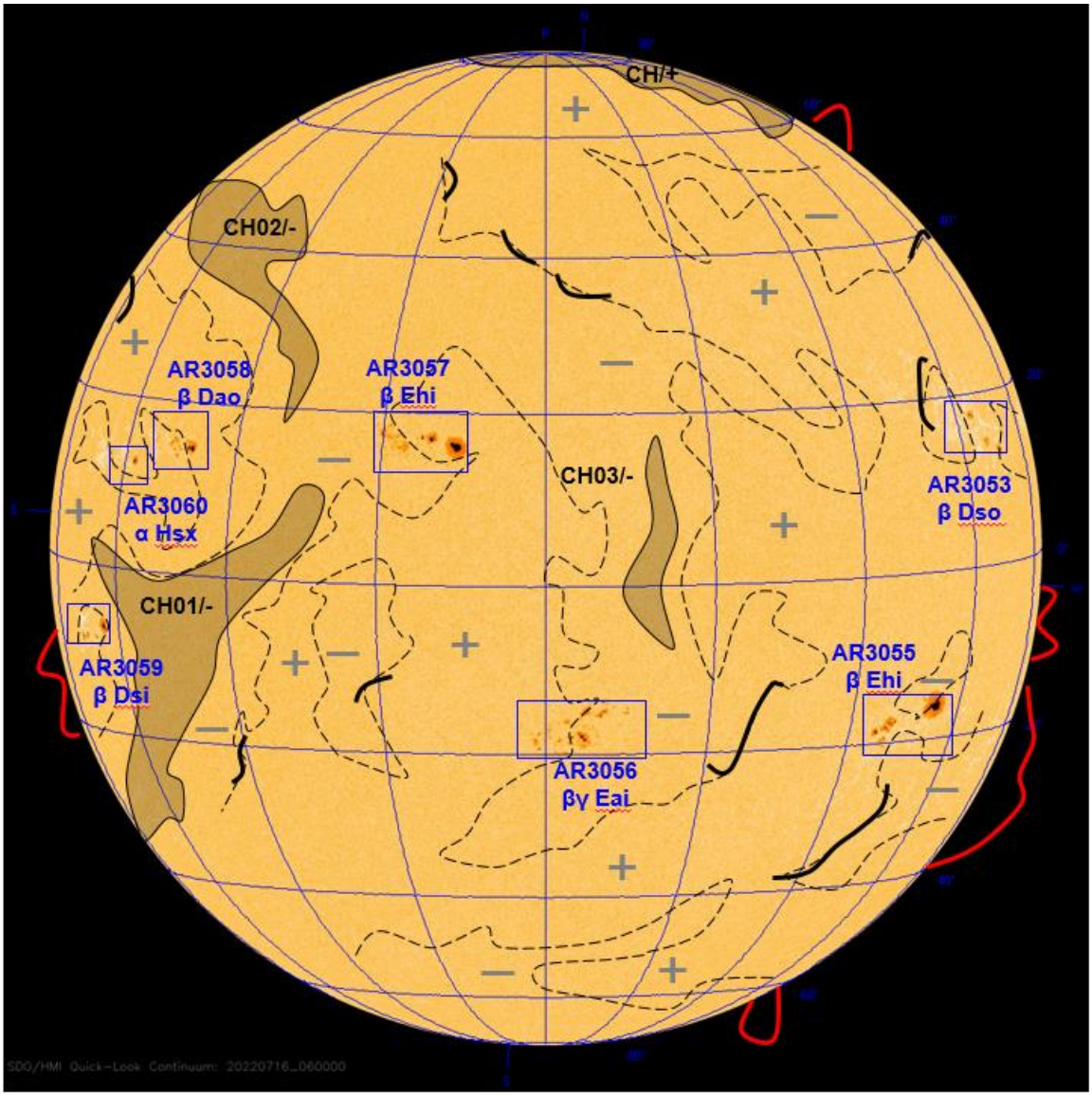
above, and any high speed stream from CH03. The slow speed of the assessed CME and the prospect of a second one along a similar track (TBC) may result in the risk of G1 extending through midweek UTC before easing.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is likely to remain at Background levels, but with a daily Slight Chance of S1 or greater due to the presence of large sunspot regions in the west or near centre-disc.

The high energy electron flux (greater than 2 MeV) is expected to increase over the coming days, with diurnal maxima likely to exceed the High (1e3 pfu) threshold for more prolonged periods as the weekend goes on. Fluence levels are also expected to increase, with Active (1e8 integrated pfu) fluence Likely by Days 3 and 4 (18-19 July).

Figure 1. Solar Analysis Valid 16/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The 15/1300UTC filament CME is due at the very end of the current forecast period, around the turn of the UTC day Tuesday 19 into Wednesday 20 July. A second CME from a similar location produced 16/0300UTC is undergoing assessment. No other CMEs feature. Any CME from the second main filament eruption 16/0300UTC carries a chance of amalgamating with the first should it leave the immediate solar environment, having previously occupied a similar location on the disc, and potentially finding itself with a swept-out interplanetary medium. This may change the future chances of G1 on Tuesday (and Wednesday), however for now the risk is assessed as a Chance.

In addition to the major component of the forecast above, two fast wind streams may feature in the forecast: firstly an exit from the long-peaked current CH99/+ high speed stream; and secondly minor influence from CH03/- on day four (Tuesday 19 July). The second of these features is relatively ill-defined on the current disc, but its appearance is a reasonable analogue with last pass and it is expected to be the minor player given the transients due around the same time.

All considered, activity should soon decline to Quiet, but increase to a (probably protracted) Chance of G1 on Tuesday 19 July from the combined effect of the 15 July CME mentioned above, and any high speed stream from CH03. The slow speed of the assessed CME and the prospect of a second one along a similar track (TBC) may result in the risk of G1 extending through midweek UTC before easing.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/0209	Partial	Filament eruption	NW quadrant	395km/s	Turn of UTC day Tuesday 19 into Wednesday 20 July	May yet be bolstered by subsequent CME from similar location, TBC

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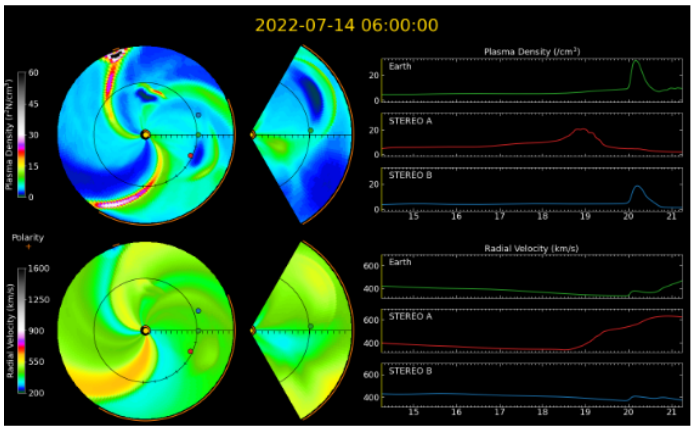
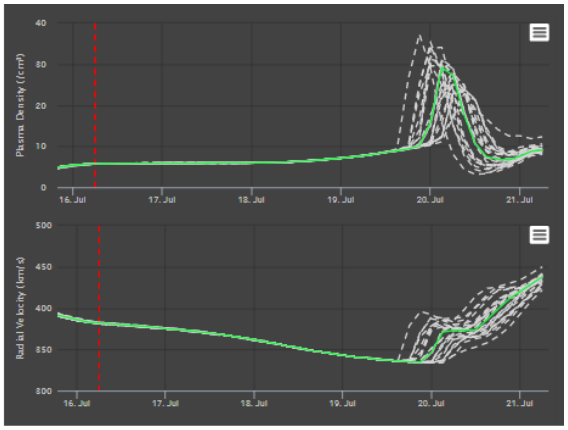
Figure 2: Latest MOSWOC Enlil model and ensemble showing 15/1300UTC filament CME's most likely arrival on or around the turn of the UTC day Tuesday 19 July into Wednesday.





Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate during the last 24 hours, and further M-class events remain Likely given the sheer number of large and (on paper) complex sunspot regions, even if their flare rate and magnitude is currently a little below expectations.

Considering the overall balance of sunspot groups, two regions are due to leave the disc on Days 3 and 4 (18-19 July). This results in a slight decrease in the probability of flaring towards the end of the period. Arriving bright flux over the eastern limb may compensate for any loss, however this will be assessed as and when this region arrives over the northeastern solar horizon.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	50	40
Very Active	R3 to R5 X Class	No	10	10	5	5

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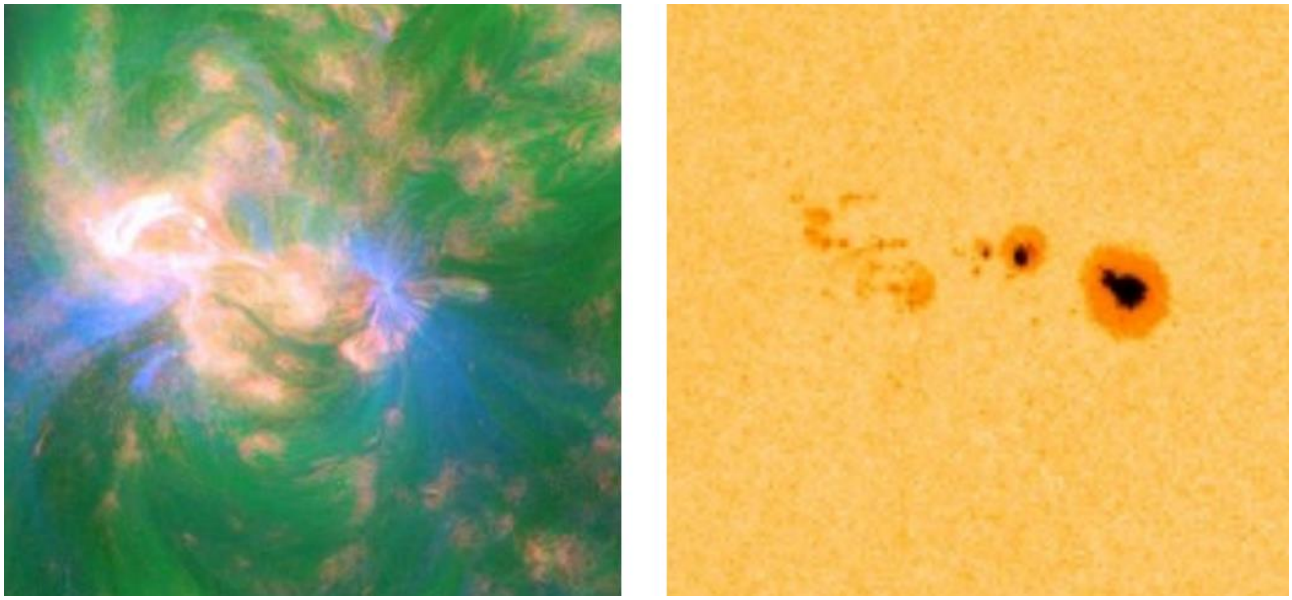
Figure 3: (Left) AIA composite 171, 211, 304 composite image of the 16/0629UTC M1.1 flare from AR3057, with the spot group as it appeared visually at that time shown in the image on the right. The main changes in the group were observed in the proliferating trailing sunspots, with this being the location of the flare.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently at Background levels. Owing to the complexity of the current disc, and in particular several large regions in the west or near centre-disc, there is a daily Slight Chance of S1 or greater occurring.

Sub-S1 events of the past week were tied to a feature (Ex-3047) that is now long since past its peak geoeffective location (being several days onto the far side), and none of the present front-side sunspots have any history of any proton enhancement so far.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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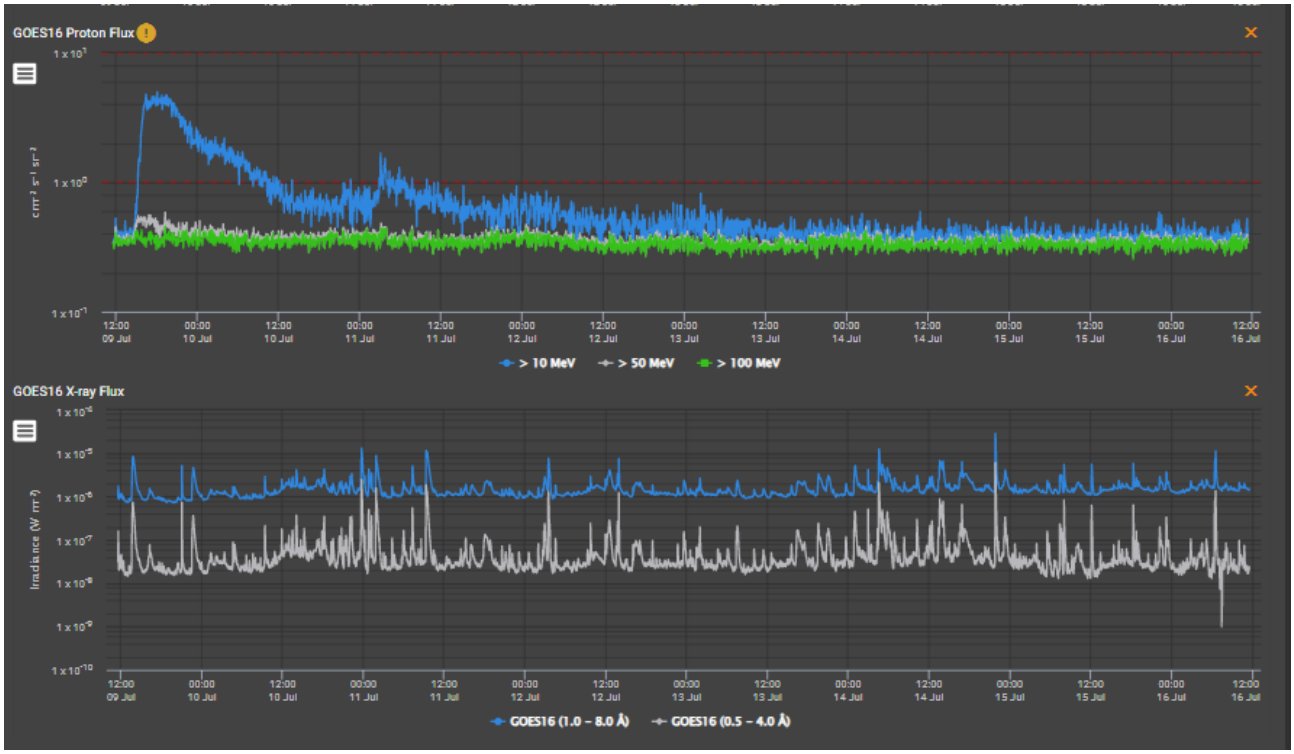
Figure 4: Past week in GOES16 high energy proton spectrum response to increasingly westward (on far side) Ex-AR3047.



High Energy Electrons Event (≥ 2MeV):

The diurnal variation in high energy electron flux (greater than 2MeV) is currently peaking at High levels, with an overnight UTC upward response seen in flux as geomagnetic activity from CH99/+ has eased. This elevated solar wind speed ought to establish a new stable oscillation over the current UTC weekend as it eases further.

Persistence from the last rotation is offering a reasonable match for current observations, adding credence to the suggested increase. An anticipated CME arrival from the 15/1300UTC filament eruption CME may arrive at the very end of the current forecast period, however this means that any resultant compression or redistribution of electrons is largely expected to be around midweek.

Fluence is expected to rise during this period, with Active (1e8 integrated pfu) becoming likely into the new UTC working week. MOSWOC REFM's latest increasing fluence signal is therefore accepted.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	50	70	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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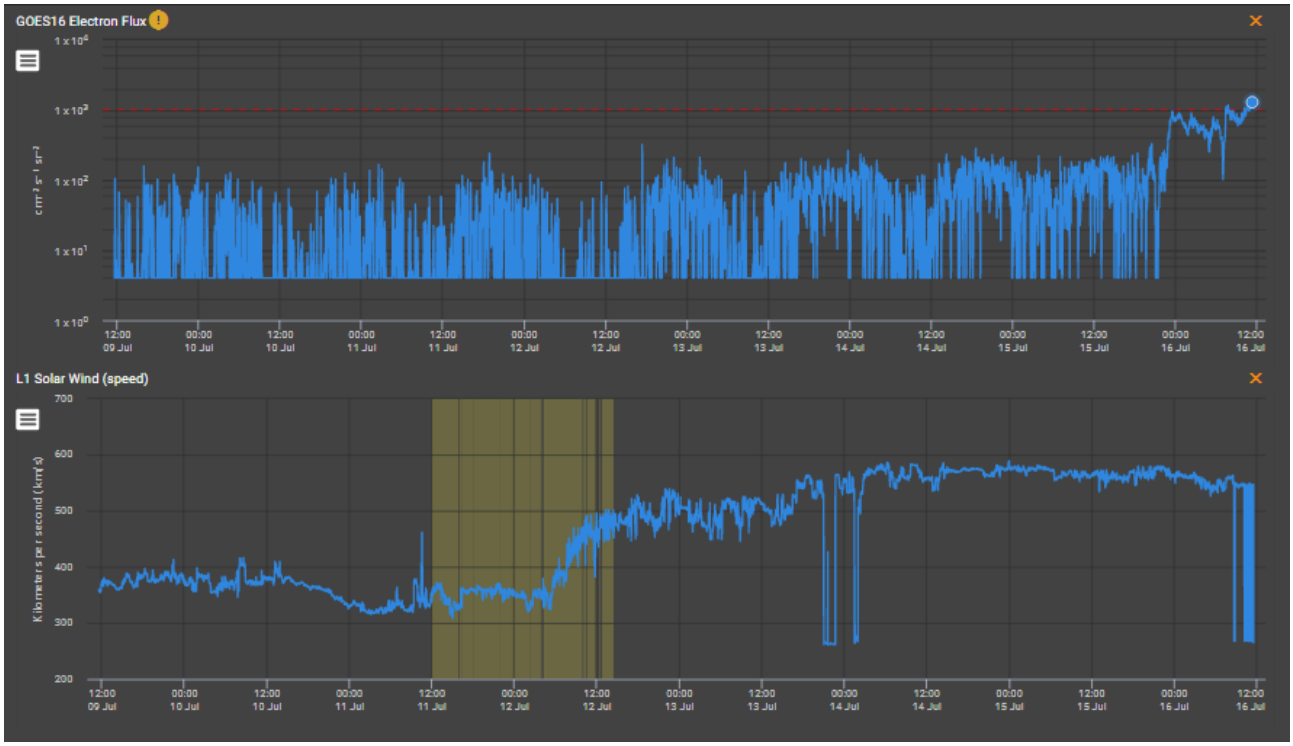
Figure 5: Past week in GOES16 high energy electrons, with driving L1 solar wind speed shown below. A new diurnal oscillation is in the process of becomig etablished at the time of writing.



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